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A HALF CENTURY OF PROGRESS IN THE FIELD OF MEDICAL ENTOMOLOGY IN THE STATE OF FLORIDA [1]

J. A. MULRENNAN
Florida State Board of Health, Jacksonville

Florida could be classed as the Crown Jewel of the North American Continent, in that it stands out as a shining light by the brilliance of its sunshine and by the pointed fact that it is a peninsular, giving life to a luxurious flora and to an abundant and unique fauna.

It would seem natural that the Great Creator should have guided the first explorers to the land of sunshine and flowers with all of its splendor and beauty which became a mecca for the naturalists in the early days following her discovery.

The cradle of American democracy with its pearly white beaches bathed by the blue-green waters of the briny deep surrounding the great paradise now known as Florida was also to experience the bitter with the sweet.

The early settlers were to suffer crippling losses from the stings of mosquitoes which caused the people to stagger and fall under the yoke of malaria; to have their bones seemingly break from the scourge of dengue fever and to go into panic at the mention of yellow fever, all known today to be transmitted by mosquitoes.

Malaria, under a variety of names, has been a terrible scourge to the people of Florida. Until very recent times it was, in fact, the pestilence of Florida. By coincidence, or otherwise, the early settlements were almost entirely within what was later defined as the "Malaria belt" of the State. Tallahassee, the capitol, was in the midst of this region. The following statement from an early work ("Views and Recollections of North America" by the Count of Castlenau, 1842) reveals what malaria meant to the Tallahassee of a hundred years ago. "But unfortunately in opposition to these numerous advantages there are the greatest plagues that can afflict a new settlement; and unhealthful climate; every year bilious fevers of a most dangerous nature spread consternation in the whole region. Then all the shops are closed, the fear of the epidemic and the stifling heat caused the planters of the neighborhood to leave the city, and all the inhabitants who can afford the expense of this kind

[1] Presidential address given at the 33rd Annual Meeting of the Florida Entomological Society, December, 1950.

go to the northern part of the United States to seek a more salubrious climate; the merchants take advantage of this season to go to New York or Philadelphia to place their orders, and the planter goes to Niagara or Saratoga Springs to display his luxury and spend in three months his year's revenue.

"However, although the climate is dangerous for strangers at all times, the most insalubrious months are August, September, October, and November; then no one can be sure of escaping the plague, neither the planter who has been settled in the country for years, nor the negro born in the midst of the miasma of Carolina or under the burning sun of Georgia. The comparative extent of the huge cemeteries is a sad warning for one who, charmed by the beauty of the sight, would want to establish himself in this region."

The insalubrious situation prevailed in a vast number of Florida towns and rural areas until as recently as twenty years ago. Malaria, the greatest of debilitating diseases, caused misery, poverty, and general economic distress on a scale hardly to be appreciated by the people of today's Florida.

The story of yellow fever in the State is one of fright and panic which gave birth to the present State Board of Health. The epidemic of yellow fever in Fernandina and Jacksonville in 1877 is inscribed in the archives of the rich history of this State as the greatest holocaust to ever strike the State. Time does not permit to review in detail this great catastrophe but it can be said that a census of Fernandina, taken on September 20, had shown a population of 1632, with 1146 cases of fever reported. There are 24 deaths, a mortality rate of about 5½ percent of the total population. Among the white people the mortality rate was about 16 percent while among the colored it was less than one percent.

The direction of approach to the control of malaria was recognized in Florida as early as 1900 by Dr. Porter, the State Health Officer, when he stated, "It was observed that the attacks (of malaria) were more than usually fatal along the river bottoms, marsh lands, and in the flat woods country.—It now is seen that it is not the germ itself which rises from the soil or water but the *carrier of the germ.*"

However, despite this early recognition of the means at hand for controlling malaria, no concerted effort was made in the direction until World War I period. At this time, drainage and larvicidal measures were introduced at Camp Johnston in

a joint effort of Army, U. S. Public Health Service, and State Health Department as a part of the general sanitation program around military establishments.

After this initial start, the State Health Department undertook its first malaria control project, in the City of Perry, a typical malarious community in Florida. At that time it was one of the largest projects of the kind in the country and involved the removal of 47,000 cu. yds. of earth for drainage canals and ditches at an expenditure of $28,000. The cost of the project was borne by the City of Perry, the county of Taylor and the Burton Swartz Cypress Company with the State Board of Health supplying the technical supervision. A subsequent letter from the lumbering plant stated that they had been more than repaid for their share of the cost by increased output resulting from the better health of their employees.

The first great forward step in the control of mosquitoes in this State was the organization of the Florida Anti-Mosquito Association in 1922. This organization has performed a momentous duty in the promotion and coordinating of the mosquito control activities in the State.

Another milestone was reached in 1931 when the Rockefeller Foundation established a Malaria Control Research Station at Tallahassee, Florida, to work in conjunction with the Florida State Hospital at Chattahoochee and the Florida State Board of Health. This station from 1931 until its termination in 1947 performed work in the malaria field of inestimable value not only to the State of Florida, but to the world as a whole.

Florida received further recognition in the mosquito control research field when the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine established in 1932 a mosquito research station at Orlando which is still functioning today and has received world-wide recognition. This recognition was quite evident during World War II when practically all of the research work pertaining to insects of medical importance was carried out in the Orlando laboratory. The work of this station has been of great value to the mosquito control districts and also the citizens of Florida. Their counsel and advice, as well as the investigations which they have carried on in the field of mosquito control has assisted greatly in alleviating diseases transmitted by mosquitoes in Florida as well as helping those in charge of mosquito control work to carry

out more effective and economical control procedures in the State.

In 1941 a Bureau of Malaria Control was established in the State Board of Health to study and make recommendations for controlling malaria in the State. The Bureau of Malaria Control gave way in 1946 to the present Division of Entomology whose scope of activity was to cover all activities pertaining to all arthropods transmitting human diseases, or annoying man by their bites.

Next to the mosquito, the rat flea has brought about a considerable blight on the State in recent years. In 1920, 10 cases of plague were reported in Pensacola. During this outbreak, seven deaths were reported. No cases have been reported in the State since this outbreak. Endemic typhus fever began to appear in 1918 and by 1944, 483 cases were reported with 32 deaths. In some of the larger cities, 83 percent of the rat population was found infected with typhus.

It can be said that great strides have been made in the eradication of human diseases transmitted by mosquitoes. It has been over fifty years since a case of yellow fever was transmitted in the State. The last big epidemic of dengue fever occurred in the early thirties. The City of Miami and Tampa both had epidemics in 1932. The last evidence of transmission of malaria occurred in Naples, Florida, in 1948.

It would seem safe to say that the disease malaria has been eradicated from the State. It must be remembered, however, that as long as malaria is alive in other southern states and also in the world, the disease could spring up in a localized area in the State.

The eradication of malaria from the State, in my opinion, is one of the classic accomplishments which has occurred in the State in the past 50 years. When we look back as recently as 1929 and find that 470 individuals died from the malady and for every death there is an estimated 400 cases, it can be seen that the disease malaria cost this State a tremendous sum.

The disease endemic typhus is being brought under control in Florida and in a few more years it may be completely eradicated from the State. This year up to the present time there have been only 34 cases reported. The main tool that has been so effective in eradicating malaria and bringing typhus under control is DDT.

The one great problem which still confronts the State is the mosquito and human-biting fly problem. This is a gigantic problem and one that affects the economy of the State, not only from the standpoint of transmission of diseases to animals, but also by annoying and destroying animals by their bites. The greatest economic loss, however, brought about by mosquitoes is their annoyance to humans and most especially to summer tourists who come to the State to enjoy our wonderful beaches and the many other great attractions found in the State.

It is true that great strides have been made in organizing mosquito control districts. At the present time there are 19 mosquito control districts in the State. The counties and State are spending approximately one million dollars a year on mosquito abatement.

There is a tremendous amount of investigational work which must be performed if we are to find a solution to this mammoth problem. We do not have the tools at our command today which would enable us to even consider eradication of some of the pest species of mosquitoes. In fact, we do not have tools which are sharp enough at times to give us satisfactory control and until we find ways and means of economically controlling pest mosquitoes, the State will continue to lose thousands of dollars each year in driving people from the State, most especially during the summer months.

The citizens as well as the visitors who come to the State will continue to be annoyed by the bites of mosquitoes and other arthropods, but there should be some consolation to the individual to know that their chances of contracting an arthropod-borne disease in Florida is considerably less than any other southern state or any other state having similar climatic conditions.

The State, which was at one time considered a teeming jungle full of mosquito-borne disease, is now becoming the haven for old folks as well as a winter and summer play grounds for many people from all over the United States as well as from the countries to the south of us. Yes, I think we can say that it is becoming the nation's choice.

We must never relax our efforts in the field of medical entomology, but should continue to try and develop more effective means of controlling arthropods of medical importance so that Florida may become not only disease free, but pest free as well.

THE OCCURRENCE OF SALT MARSH MOSQUITOES IN THE INTERIOR OF FLORIDA [1]

MAURICE W. PROVOST
Florida State Board of Health, Jacksonville

The salt marsh mosquitoes of Florida referred to in this paper are *Aedes taeniorhynchus* primarily and *Aedes sollicitans* incidentally. To the best of our knowledge these mosquitoes deposit their eggs on moist ground in low areas which are likely to be flooded at a later date by either tide or rain water. They do not oviposit and develop only in salt marshes. Although the soil where the eggs are laid is usually saline, the water which hatches them is generally fresh rain water. If the greatest producers of these mosquitoes are salt marshes and mangrove swamps, it could justifiably be argued that it is because these are the most available temporary-water habitats in coastal areas and not necessarily because of preferability to the mosquitoes. The same grassy swales, grassy ditches, and other like depressions commonly referred to as rain pools which produce salt marsh mosquitoes in coastal areas produce glades mosquitoes, *Psorophora confinnis*, away from the coast. Without elaborating any further on a complex problem, we might say that the salt marsh mosquitoes appear to be restricted to the coastal strip because of adult requirements rather than of larval ecological limitations. What it is that the adults require which restricts them to the coast we can only surmise, and it is highly probable that a knowledge of these requirements would give us the answer to the riddle of their remarkable flights.

Before discussing exceptional occurrences of salt marsh *Aedes* in the interior of Florida, let us review briefly their normal distribution with respect to coast line. An examination of our data reveals that the presence of adult salt marsh mosquitoes in Florida in annoying numbers beyond four miles from tidewater is exceptional. Arbitrarily, we consider annoying numbers a landing rate greater than one per man per minute or a light trap rate greater than 24 females per night. And by exceptional we mean occurring less than three days out of a year, or 1% of the time. As an example of the close restriction of these mosquitoes to tidewater areas, we have data from

[1] Presented at the 33rd Annual Meeting of the Florida Entomological Society, December, 1950.

Broward County in 1948. Twice a week during July and August, landing rates were taken at 22 stations distributed evenly over the populated portion of the county. One row of stations was within two miles of salt water, a second row was parallel to the coast and from three to five miles from tidewater, and a third row was at right angles to the other two rows and ended well within the Everglades 25 miles due west of Ft. Lauderdale. Not a single specimen of salt marsh mosquito was either seen, counted, or collected at any of the stations in row two or row three although they occurred regularly in August at stations in row one. On the Gulf coast, a light trap operated semi-weekly and without interruption for four years at Alva, 10 miles east of tidewater in the Caloosahatchee River, has caught over 24 female *Aedes taeniorhynchus* three times in 1947, not once in either 1948 or 1949, and three times in 1950. The largest collections were 53 females on June 27, 1947, and 43 females on September 8, 1950. We have a similar record for three years at Myakka River State Park, roughly 10 miles from tidewater in the Myakka River. In 1948, the greatest collection of female *Aedes taeniorhynchus* was nine. In 1949, there was a collection of 128 on June 28 and one of 40 on July 15. The only collection exceeding 24 in 1950 was one of 40 on July 15. Numerous other trap records verify the general assertion made that more than four miles from tidewater in Florida, *Aedes taeniorhynchus* in significant numbers is exceptional.

Now we may consider some of the exceptional occurrences of this salt marsh mosquito in the interior of Florida with attempts at explanation. Considering first a locality fairly close to the coast, we have light traps operating semi-weekly at Princeton and Modello just north of Homestead in Dade County. These towns are roughly five or six miles west of the Biscayne Bay coast, which in this area is fairly straight and narrowly fringed with mangrove. In 1948 and 1949, these traps had *Aedes taeniorhynchus* records almost identical to the ones for Alva and Myakka, across the peninsula. In 1950, both traps swung to salt marsh mosquitoes in quantities typical of tidewater areas. The Princeton trap exceeded 100 female *Aedes taeniorhynchus* per night 15 times and reached a high of 688 on August 29 and October 3. The Modello trap exceeded 100 per night seven times and reached a maximum of 1800 on August 22. The male of the species never reached 50 per night

at either station. With salt marsh mosquito experience of many years and basing his judgment on the bone-dry condition of known breeding areas and on the failure of his inspectors to locate breeding anywhere near the affected areas, Mr. Fred Stutz, Director of the Dade County Anti-Mosquito District, believes that the Miami area in 1950 was invaded by *Aedes* originating in the Cape Sable and southern Everglades wilderness region, where breeding of salt marsh mosquitoes over tremendous areas is a distinct possibility. If this assumption is correct, these mosquito swarms reached the Miami area, 40 to 80 miles away, by advancing at right angles to the prevailing southeasterly trade winds. In this connection, it is notable that the numbers of salt marsh mosquitoes in the Alva trap mentioned above were synchronized over a four year period with numbers in the great breeding areas of San Carlos Bay, 30 miles to the west. It, therefore, appears that the occurrence of salt marsh mosquitoes in the interior of the southern tip of Florida is best explained as the result of long-distance, swarming flights.

Farther inland, but still in south Florida, we will consider the record for Belle Glade, on the southeast shore of Lake Okeechobee, some 30 miles from the nearest tidewater. A light trap has been operated here by the Agricultural Experiment Station for six years at semi-weekly intervals. For four years, 1945 through 1948, the trap collected only occasional *Aedes taeniorhynchus*. Only two collections exceeded 24 females; 36 on July 23, 1945, and 48 on August 10, 1948. There were only seven collections (largest, nine) in 1946; in 1947 there were only four collections (largest, two). From this scarcity, the same trap in 1949 showed a huge increase in *Aedes taeniorhynchus*. All, however, came within the brief period—June 22 to July 3. Several collections in this period were over 100 females, the largest being 232; the largest male collection was 20. It had all the appearance of being one big brood that had blown in. Previous to June 22 and after July 3, the record was very much as it had been in the four previous years.

We can now discuss the most outstanding occurrence of salt marsh mosquitoes in the interior of Florida. During the years 1942 to 1945, the Army operated light traps at their installations in Sebring and Avon Park. The *Aedes taeniorhynchus* record for these traps is astounding. The nearest tidewater is the head of Charlotte Harbor, 30 miles to the southwest; the

east coast at its nearest (Vero Beach) is 45 miles away. The prevailing summer winds here are southeasterly trade winds. A foretaste of things to come was obtained when traps were first set up in the fall of 1942. Throughout October the traps at Sebring gathered in large numbers of *Aedes taeniorhynchus*, the peak being reached on October 12 when one trap picked up 134 males and 73 females. The identical pattern, though of much smaller numbers, occurred at Dorr Field, halfway between Sebring and Charlotte Harbor. In 1943, two large broods occurred in Sebring. The first and largest lasted from May 31 to June 12 with a maximum of 914 females in one light trap collection. The second brood lasted from June 25 to July 11 with a maximum collection of 145 females. Smaller broods occurred in each month from April to November. Again we find these same two large broods recorded at Dorr Field, the early June one reaching a maximum collection of 271 and the early July brood reaching a maximum of 89 females. During these infestations, there were never as many as ten males in a collection at Sebring. At Dorr Field the males rose to 103 in the early June brood. On the entire Atlantic seaboard there were no *Aedes taeniorhynchus* to match the May 31 to June 12 brood at Sebring and Dorr Fields. On the Gulf coast, there was a big brood culminating on the 1st of May in the Tampa Bay area, but that was a whole month prior to their appearance at Sebring. The only region receiving sufficient rainfall between May 17 and 24 to have produced the mosquito brood was neighboring Polk County, where no salt water occurs. At Sebring and Avon Park, 1944 was a repetition of 1943 except that there was but one large brood lasting from June 2 to June 26. The largest single night's trap collections of female *Aedes taeniorhynchus* were 348 at Sebring and 1144 at Avon Park. Males were scarce in these collections, the largest numbers being 19 and 3 respectively. As in 1943, this brood had no counterpart on either coast, to our knowledge; and also as in 1943, the only rainfall area properly timed to produce such a brood was in neighboring Polk County. In 1945, there was a large brood in July at Avon Park and Sebring, but this time contemporary broods occurred throughout peninsular Florida including the interior where local record collections of *Aedes taeniorhynchus* were made at such widely separated points as Clewiston (365) and Leesburg (37). At the proper time previous to this big brood, there had been torrential rains all over

Florida, although again Polk County led with a record of 12.52 inches of rain at Lake Wales on June 24.

Northward in the interior of Florida, collections of *Aedes taeniorhynchus* become less frequent and smaller. Traps operated at such points as Bartow, Lake Wales, Kissimmee, and Orlando usually bring in a dribble of salt marsh mosquitoes, but never as much as 24 per night or even near that. At Leesburg a large number of traps were operated daily in 1948 and 1949. The largest single collection of female *Aedes taeniorhynchus* in one night was eight on July 19, 1948. Back in 1945, as mentioned earlier, one trap did collect a record of 37. By adding up the totals for all Leesburg traps operating daily in 1948, we arrive at a considerable sample. This readily demonstrates two broods in June and July. It seems more than coincidental that these mosquitoes showed up in Leesburg in both cases within three days of demonstrated huge emergences in the salt marshes of Brevard County, 60 miles away to windward. A third big brood emerged there on August 22 to 24 and was followed by a sharp rise in Leesburg traps on August 31 and September 1.

Proceeding northward from Leesburg, records of salt marsh mosquitoes in Florida's interior soon become exceedingly rare. Intensive trapping in the Orange Lake area in 1950 yielded a maximum night's collection of eight females at McIntosh, and three traps operating almost daily in Gainesville during the summer of 1948 failed to yield a single *Aedes taeniorhynchus* or *Aedes sollicitans*. A very large number of traps operated continuously in the Tallahassee area in 1943 and 1944 yielded only occasional *Aedes taeniorhynchus* and *Aedes sollicitans*, although the extensive salt marshes of Wakulla County are but 20 miles away and the prevailing summer winds are from their direction. The only salt marsh mosquito collection to exceed four in one night was 80 females on July 25, 1944, which was obviously a flight. Orange Lake, Gainesville, and Tallahassee are referred to because they represent intensive trapping. North Florida was fairly peppered with light traps between 1942 and 1945, and evidence of salt marsh mosquitoes at interior points was consistently negligible.

Summarizing the data reviewed, the following tentative conclusions can be drawn concerning the occurrence of salt marsh mosquitoes in Florida: (1) *Aedes taeniorhynchus* and *Aedes sollicitans* are normally restricted to within four miles

of tidewater. (2) Although *Aedes sollicitans* adults have been collected throughout the interior, only *Aedes taeniorhynchus* has occurred here in annoying numbers. (3) With one exception (Avon Park - Sebring), *Aedes taeniorhynchus*, both in frequency and size of collections, decreases in the interior in a perfect gradient from south to north. Avon Park is the farthest north where they have been recorded in nuisance numbers, and north of Leesburg there are very few light trap collections exceeding five per night for the interior. (4) Again with the exception of Avon Park - Sebring, interior occurrence of salt marsh mosquitoes are explainable as flights from the coasts and do not necessarily indicate breeding in the interior. (5) The remarkable numbers of *Aedes taeniorhynchus* in the Avon Park - Sebring area in 1943 and 1944 are virtually impossible to explain as invasions from either coast, and most likely originated somewhere in the interior of Polk County, if not right there in Highlands County.

As a postscript, we might add that, to our knowledge, there has been but one proven case of breeding of *Aedes taeniorhynchus* in interior Florida. That was in Orlando some years back and was discovered by workers of the Bureau of Entomology and Plant Quarantine.

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DICTYOSPERMUM SCALE CONTROL ON AVOCADOS

D. O. WOLFENBARGER
Sub-Tropical Experiment Station, Homestead, Florida

The dictyospermum scale, *Chrysomphalus dictyospermi* (Morgan), was reported by Moznette (1922) to be the most important scale insect pest on avocado in Florida. It was reported by Wolfe, et al (1934) as the most destructive insect attacking the avocado in both nursery and grove. It was first reported from California, and is occasionally found there on lemons and avocados, but it has never become abundant nor widespread, according to Ebling (1949).

The dictyospermum scale is generally distributed in Florida where it is occasionally serious in some avocado groves. Young trees seem to be more seriously attacked than old trees. Some varieties, the Trapp and the Lula for example, are more seriously infested than others. Trees sprayed with bordeaux mixture 6-6-100 were found more heavily infested than where a neutral copper spray was used, according to Ruehle (1938).

Grove caretakers make little or no effort to control this insect, for several reasons. They now regard the dictyospermum scale as a minor insect pest in avocado production. Oil emulsion sprays occasionally used for scale control have frequently caused heavy leaf fall. High spray pressures and thorough coverage are necessary for most effective control. Grove caretakers, furthermore, report that the oil emulsion spray treatments have been but partially effective. These considerations have made attempts at scale control unpopular and illustrates the need for an improved insecticide.

Oil emulsions of 1.0 and 1.3 percent oil were reported by Cressman (1933) to have given practically perfect control of the dictyospermum scale. Two spray applications, each of 1.4 percent oil, separated by a three-week interval during the dormant season were recommended by Moznette (1922) to control the scale. This recommendation has been repeated since with only slight modifications.

EXPERIMENTAL

Experiments were conducted on trees where the dictyospermum scale populations were variable, from few insects on some trees to more numerous infestations on others. Con-

ventional power spray machines were used for spraying the trees in all experiments. The dictyospermum scale ordinarily infests the bark of branches and twigs. Samples of these were taken from different parts of treated trees for examination to determine treatment effects. Bark areas of from one to eight square centimeters each were cut from infested portions of the trees. Each section of bark was measured, then examined under low power (9x) of a binocular for any living scale. By means of the bark area measurements and the number of living scales on the bark the data were reduced to average number of live scales per square centimeter for each tree. There was considerable variation, however, in the data obtained.

An experiment was started in January, 1948, by spraying seven-year old trees of the Booth-7 variety. The bark samples were taken two weeks after the spray treatments. A summary of the data is given in Table 1.

TABLE 1.—RESULTS OF SPRAY TREATMENTS FOR DICTYOSPERMUM SCALE CONTROL.

Treatment	Bark area examined, sq. cm.	Avg. No. live scales per sq. cm.	Control, percentage
Parathion, 25% w. p. 2 lbs. per 100 gals. water	126	0.072	69
Oil emulsion, 2% oil content	123	0.065	71
Check	123	0.228	—

The parathion and oil emulsion sprays were practically equal in effectiveness. Less than one-third as many living scales were found on the sprayed as on the unsprayed bark samples. Although the concentrations of spray were more than are ordinarily used no apparent plant injury was observed following the spray treatments.

Part of the Sub-tropical Experiment Station 17 year old trees of the Lula variety was found infested with the dictyospermum scale. The infested trees of the planting were divided into plots for an experiment and were sprayed in December, 1949. Samples of bark were removed and examined at three and at six weeks after the spraying. The results are summarized in Table 2.

TABLE 2.—RESULTS OF SPRAY TREATMENTS FOR DICTYOSPERMUM SCALE CONTROL.

Treatment (amount of parathion is given in lbs. 15% w.p./100 gals. water)	Bark area examined, sq. cm.	Avg. No. live scales per sq. cm.	Control, percentage
Three weeks count			
Parathion, 1 lb.	136	0.023	66
Parathion, 2 lbs.	101	0.022	67
Parathion, 4 lbs.	136	0.025	63
Oil emulsion, 1½% oil	115	0.023	66
Check	193	0.067	—
Six weeks count			
Parathion, 1 lb.	122	0.014	78
Parathion, 2 lbs.	157	0.004	94
Parathion, 4 lbs.	182	0.019	71
Oil emulsion, 1½% oil	207	0.083	—33
Check	202	0.063	—

The data taken after three weeks show that all spray treatments were nearly equal in effectiveness, and that all had approximately one-third as many living scales per square centimeter as the samples from the unsprayed treatment. The data from the six weeks count show that the parathion sprays were more effective than the other treatments. The data on the six weeks count were statistically significant at the five percent level, with a least mean difference of 0.057 live scale per sq. cm.

The data obtained in Table 2 came from trees that were the largest of any in the experimental groups. Samples were taken in these trees at heights of from about 10 to 18 feet from the ground. No attempt, however, was made to determine control effects at the different heights.

Eight-year old trees of the Booth-7 variety were also used for a dosage experiment with parathion, applied in January, 1949. The results of counts made three weeks after spraying are summarized in Table 3.

Parathion was more effective at two and four pounds than at the one pound dosage.

Two-year old avocado trees of different varieties were sprayed to evaluate oil emulsion, parathion, and oil and parathion combined for dictyospermum scale control. This was a

TABLE 3.—RESULTS OF PARATHION SPRAY TREATMENTS FOR DICTYOSPERMUM SCALE CONTROL.

Treatment (amount of parathion is given in lbs. 15% w.p./100 gals. water)	Bark area examined, sq. cm.	Avg. No. live scales per sq. cm.	Control, percentage
Parathion, 1 lb.	71	0.032	65
Parathion, 2 lbs.	112	0.003	97
Parathion, 4 lbs.	25	0.007	91
Check	91	0.092	—

cooperative experiment and replications of treatments were obtained by taking samples from different trees in each treatment strip. The trees were sprayed in December, 1948. Three weeks later bark samples were examined from infested portions of from eight to 13 infested trees of each treatment. A summary of the data is given in Table 4.

TABLE 4.—RESULTS OF SPRAY TREATMENTS FOR DICTYOSPERMUM SCALE CONTROL.

Treatment (amount of parathion is given in lbs. 15% w.p./100 gals. water)	Bark area examined, sq. cm.	Avg. No. live scales per sq. cm.	Control, percentage
Parathion, 1 lb.	117	0.014	84
Oil emulsion, 1½% oil	121	0.037	58
Parathion, 1 lb. plus oil emulsion, 1% oil	68	0.070	20
Check	56	0.088	—

It will be noted from Table 4 that the fewest scales were found on the parathion and the most on the check treatments. The oil emulsion ranked second, and the oil emulsion-parathion combination ranked third in having the lowest average number of living scales per square centimeter.

SUMMARY

The percentages of control from the treatments in the above tables were averaged to give figures on the over-all control obtained from all tests, and are given as follows:

Parathion, lbs. 15% w.p./100 gals. water			Oil emulsions
1	2	4	
70	86	74	41

The data show that two pounds of 15 percent wettable powder was the most effective, and that oil emulsion was the least effective. Although more work is needed on dictyospermum scale

control on avocados the results indicate that parathion is fully as effective as the oil emulsions previously recommended. The results, furthermore, confirm grove caretakers reports that oil emulsion is but partially effective on the dictyospermum scale.

LITERATURE CITED

Cressman, A. W. Biology and control of *Chrysomphalus dictyospermi* (Morg.). Jour. Econ. Ent. 26: 696-705. 1933.

Ebling, Walter. Subtropical entomology. Pp. 469-471. Lithotype Process Co. San Francisco. 1949.

Moznette, G. F. The avocado: Its insect enemies and how to combat them. U. S. Dept. Agric. Farmers Bul. 1261: 1-31, illus. 1922.

Ruehle, G. D. A study of diseases of the avocado and mango and development of control measures. Fla. Agric. Expt. Sta. Ann. Rept. for 1938: 191-192. 1938.

Wolfe, H. S., L. R. Toy and Arthur L. Stahl. Avocado production in Florida. Fla. Agric. Expt. Sta. Bul. 272: 1-96, illus. 1934.

REPRODUCTION OF THE BURROWING MAYFLY, *HEXAGENIA LIMBATA* (SERVILLE), IN MICHIGAN [1]

BURTON P. HUNT
University of Miami, Coral Gables, Florida

Burrowing mayflies of the genus *Hexagenia* are abundant in many lakes and streams throughout Michigan and constitute an important part of the bottom fauna in these waters. Because of the importance of the nymphs and winged stages as fish food and fishing bait,[2] a study of the biology and economic importance of various species which occur in the state was undertaken by the writer under a fellowship sponsored by the Institute for Fisheries Research, Michigan Department of Conservation. Pertinent information concerning the reproduction of *Hexagenia limbata* (Serville) is presented in this report. Data were obtained during the years 1947-1949 at Pine and Gun Lakes, Barry County; Big Silver Lake, Washtenaw County; and portions of the Au Sable River in Crawford and Oscoda Counties.

The present taxonomic status of some forms of *Hexagenia* is neither entirely settled nor completely satisfactory. Hexagenids encountered in this investigation which have been described as species by earlier workers are *H. limbata* (Serville), *H. viridescens* (Walker), *H. occulta* (Walker), and *H. venusta* Eaton. Since these forms were originally described they have been considered by various authors as valid species, subspecies or varieties (Eaton, 1871, 1883; Ulmer, 1921; McDunnough, 1924, 1927; Ide, 1930; Neave, 1932; Needham, Traver and Hsu, 1935; Spieth, 1941; Lyman (MS); and others). In a survey of the genus, Spieth (1941) concluded that all forms in which the male imago has strongly hooked penes, marginated cross veins and uneven coloration of the membrane in the costal margin of the mesothoracic wing, should be placed in a single species, *Hexagenia limbata* (Serville). He recognized as subspecies *californica, limbata, occulta, venusta* and *viridescens,* and stated that all of them except *californica* occur in Michigan. Although male imagoes collected from the waters investigated show great diversity in size, intensity of color, coloration and color pattern, all have the strongly hooked penis and uneven coloration of

[1] Contribution from the Michigan Institute for Fisheries Research.
[2] Large *Hexagenia* nymphs are used extensively as fish bait in winter angling for yellow perch, bluegills, and other pan fish in Michigan.

the costal margin of the forewing. Imagoes collected from the forenamed lakes show that the coloration and color patterns described for the forms *occulta, viridescens* and *venusta* and intergrades between the three, are present at the same time and in a single mating flight. Imagoes from the Au Sable River show color phases which agree with descriptions for *occulta* and *viridescens*, and intergrades between the two. Since the populations appear to be completely heterogeneous in their color characteristics and without discernible differences in ecology, it has been concluded that although the various described forms can be recognized they do not merit subspecific rank and should be considered as color phases or varieties of a single variable species. Therefore the author chooses to regard the species considered in this study as *Hexagenia limbata* (Serville).

The color pattern of *limbata* in the lakes studied generally tends toward that of *H. occulta* as described by Needham, Traver and Hsu (1935), and of *H. limbata occulta* listed by Spieth (1941). In the Au Sable River the color of most imagoes is somewhat darker and dorsal and ventral abdominal color patterns more pronounced and extensive than in most lake specimens. It is possible that the stream form may eventually prove to be separable from the ordinary lake form on a physiological if not on an anatomical basis. It is worthy of note that many bait dealers who handle thousands of *Hexagenia* nymphs each winter fishing season profess to be able to recognize readily nymphs which come from streams and those which come from lakes. They maintain that the stream nymphs are darker in color, are much hardier and are better fish bait than the lake nymphs.

The variability of *H. limbata* is very marked when compared to other hexagenids often encountered in Michigan. *H. atrocaudata* McD., *H. rigida* McD., and *H. recurvata* Morgan are distinct species which appear to be quite stable and show little variation in coloration or in color pattern.

Egg Production

Eggs of *H. limbata* are ellipsoid and measure 0.16-0.19 by 0.28-0.32 millimeters. All have a reticular chorionic pattern, the strands of which run nearly straight. The number of eggs produced by individual females is of considerable importance in evaluating the probable success of reproduction of the species.

Only two literature references pertaining to the number of eggs produced by *Hexagenia* are known to the writer. Needham (1920) estimated the number of eggs to be upwards of 8,000. Neave (1932) counted the eggs of two *H. l. occulta* imagoes; one contained 3,631 eggs, the other 3,388. Size of these females was not recorded. In order to ascertain more exactly the number produced, actual counts were made of eggs carried by 24 female imagoes. Preserved specimens were used and examined under a binocular dissecting microscope. Total body length was carefully measured, the abdomen opened, and eggs counted when removed from the ovaries. In most cases it was possible to count the eggs from each ovary separately. Data secured are presented in Table 1. Total number of eggs varied between 2,260 and 7,684. The greatest difference between the number in each ovary of any individual was 213. It was at once obvious that a significant relationship existed between number of eggs and body length. Plotting length and number of eggs of each individual showed a positive correlation between body length and egg production (Fig. 1). A curve drawn by inspection

TABLE 1.—NUMBER OF EGGS PRODUCED BY *H. limbata* FEMALE IMAGOES.

Locality	Body length in mm.	Wing length in mm.	Egg count		
			Right ovary	Left ovary	Total
Pine Lake	25.5	22.0	——	——	4,356
Pine Lake	24.3	21.6	——	——	3,452
Pine Lake	21.9	18.0	1,580	1,684	3,264
Pine Lake	22.4	19.7	——	——	2,731
Pine Lake	21.9	20.8	——	——	2,575
Pine Lake	22.8	20.3	1,808	1,720	3,528
Pine Lake	19.9	18.2	1,111	1,243	2,354
Pine Lake	21.2	18.3	——	——	2,841
Pine Lake	20.0	19.4	——	——	2,695
Pine Lake	20.3	17.8	1,142	1,118	2,260
Gun Lake	30.3	28.2	——	——	7,684
Gun Lake	30.2	27.6	3,653	3,440	7,093
Gun Lake	24.7	23.6	2,207	2,333	4,540
Gun Lake	27.1	25.6	3,393	3,198	6,591
Gun Lake	24.8	23.1	2,039	2,005	4,044
Gun Lake	28.4	27.0	3,299	3,230	6,529
Gun Lake	23.1	23.0	2,123	1,942	4,065
Gun Lake	24.1	22.3	1,773	1,734	3,507
Gun Lake	24.8	22.7	2,669	2,758	5,427
Gun Lake	24.7	23.3	2,406	2,417	4,823
Big Silver Lake	23.6	21.5	1,844	1,987	3,831
Big Silver Lake	27.3	24.7	2,851	2,763	5,614
Big Silver Lake	26.0	24.0	2,204	2,210	4,414
Big Silver Lake	23.8	22.2	1,938	2,140	4,078

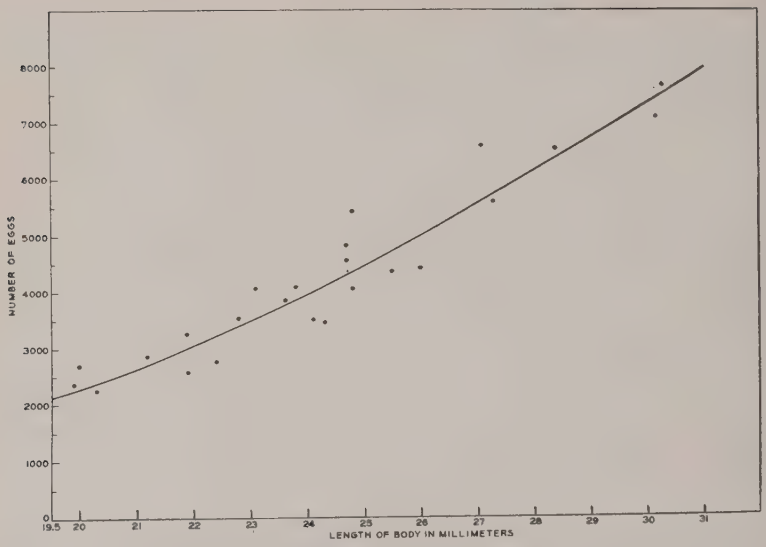

Fig. 1.—Correlation between length of body and number of eggs produced by *H. limbata* female imagoes.

indicates clearly that the relationship approaches that of a straight line. Examination of the figure shows that an average size female will produce about 4,000 eggs. Although no egg counts were obtained from females collected on the Au Sable River, there is no reason to believe the results would vary from the above.

Egg Deposition

Mating activities of *Hexagenia* and many other species of mayflies have been adequately described by Morgan (1913), Needham (1927), Neave (1932), Needham, Traver and Hsu (1935), Spieth (1940), and others. However, the deposition of eggs, the number laid, percentage fertilized, and place and time of incubation have received little attention. Mating and ovipositing flights of *H. limbata,* which take place in May, June and July in Michigan, ordinarily occur at dusk or shortly after dark. Extensive night observations by means of a powerful spotlight supported published statements that females lay their eggs on the surface of open water in both lakes and streams. Eggs were deposited in the water in three different ways. The method employed most frequently was as follows: Once the females had copulated in the mating dance, which invariably

occurred in the air along the margin of a lake and above a stream, they left the swarm and flew out over the water. After flying rapidly back and forth 10-20 feet above it for a few seconds to several minutes, the females simply plummeted erratically to the water surface. As they lay fluttering on the surface, the last two abdominal segments were raised sharply upward and the two egg packets quickly extruded by rhythmical contractions of the abdomen. Females picked up within 10-15 seconds after striking the surface had invariably discharged most of their eggs. Those which had thus "crash landed" usually drowned, for seldom were they able to right themselves and fly from the water. The second method, used by comparatively few individuals, was to light upright upon the surface, remain quiet for a few seconds, discharge a few eggs, then fly up again to repeat the performance. Some females which came to collecting lights during ovipositing flights were only partially spent. Since they easily discharged the remaining eggs when placed in contact with water, it is obvious they had been merely dipping to the surface. In the third method, observed only a few times, the female extruded the eggs while flying above the water and dropped the packets from a height of 10-15 feet. On several occasions females were seen carrying partially extruded egg packets as they plunged to the water surface. Upon contact with water the eggs separated and began to sink immediately.

Examination of various objects and material from the lake bottom showed that eggs found lodgment on aquatic vegetation, pieces of wood and small stones. Surface mud samples, obtained by utilizing a plastic tube ½ inch in diameter and 5 feet long, also contained numerous eggs, indicating that they were spread over the entire shoal area. Examination of sand from the water's edge during the height of the ovipositing season resulted in finding only 2 eggs, and suggests that few of them are washed ashore and lost. No attempt was made to obtain eggs at depths greater than 5 feet and nothing is known of the fate of those which sank into deep water. The fate of eggs released by ovipositing females in the Au Sable River was not determined.

Collection of eggs, deposited in Big Silver Lake, by means of submerged glass plates revealed that distribution of eggs on the lake bottom was very patchy. Four glass plates (total area 370 square inches), mounted individually in wooden frames

with a stabilizing weight underneath, were placed at random on the bottom in an area about 100 feet square covered with water about 3 feet deep. Eggs which settled on the glass soon became firmly attached and the plates could be raised and handled without losing them. These plates were in operation from June 20-27, 1947, during the period of *limbata* emergence and mating activities. Each day they were raised and all adhering eggs deposited the previous night removed with a small brush. The residue was examined under a microscope and the eggs counted. Average number secured was 336 per square foot of surface for the 8-night period. Quantity of eggs reaching the plates each night varied greatly, the smallest number during any night being 25 and the largest 310. Great variation was also noted in the number of eggs adhering to individual plates on any night. The indication was that eggs tended to reach bottom in clumps and were not distributed evenly over the bottom even in a comparatively small area.

TABLE 2.—TIME REQUIRED FOR EGGS OF *H. limbata* TO SINK TO BOTTOM OF A COLUMN OF STILL WATER 25 INCHES DEEP. WATER TEMPERATURE 76°F.

Trial	Approximate number of eggs	Time of sinking in seconds		
		First egg	Last egg	Median egg
1	9	152	164	160
2	20–30	150	192	155
3	50–70	150	180	160
4	20	170	190	177
5	60	175	192	180
6	100	165	194	176
7	40	160	177	165
8	50	162	177	166
9	50	150	187	178
10	75	160	197	176
11	50	152	177	157
12	50	150	175	160
13	50	153	177	157
14	200	155	192	160
15	100	157	184	174
Avg. time to sink 1 in.		6.3	7.4	6.7
Avg. time to sink 1 ft.		76.1	88.6	80.0

To determine the rate of sinking, a 1,000 cc. graduated cylinder was filled with lake water to a depth of 25 inches and allowed to stand for 2 hours. A black background and a strong light were so arranged that sinking eggs were clearly visible. Using a spatula, small lots of eggs, taken from the body of a newly-

emerged imago, were placed on the water with a minimum amount of agitation. It was noticed that the surface disturbance influenced the start of sinking of individual eggs, but after sinking began it proceeded at a uniform rate. Time required for each lot of eggs to reach bottom was recorded (Table 2). Since eggs of each lot were scattered somewhat when placed on the water, they sank in a rather scattered group. Time required for approximately one-half the eggs to reach bottom is recorded in the table under the heading "Median egg." It was found that individual eggs sank at an average rate of 1 foot in 80 seconds, but small clumps of eggs settled at a faster rate, approximately 1 foot in 60 seconds. Four to 6 minutes were required for eggs to settle to the bottom after the water was stirred vigorously.

Rate of Fertilization

Eggs obtained from a number of female imagoes captured during ovipositing flights were incubated in aerated jars to determine the efficiency of natural fertilization. Eggs in various stages are readily recognized. Those which have hatched appear as empty shells; live embryos are translucent and the embryo is visible; dead embryos are usually brown or reddish in color; and eggs which apparently were not fertilized are dark or black. A count made after hatching had been completed (Table 3) showed that in all cases more than 91 per cent of the eggs hatched (avg. 96.3 per cent). Since some embryos died during incubation, the initial fertilization rate was slightly higher. The high fertility and the large number of eggs produced by individual females point to a high reproductive potential. In nature, however, the loss of eggs and very young nymphs must be enormous.

Unfertilized eggs obtained from 7 reared virgin female imagoes were incubated for a long period. Some embryonic development occurred in a few eggs but no nymphs hatched, implying that parthenogenesis does not take place.

Artificial insemination of eggs is easily accomplished by applying macerated sexual elements of a male to the exposed egg mass of a female (Neave, 1932; Needham, Traver, Hsu, 1935). The author resorted to artificial insemination 27 different times to secure fertilized eggs for various purposes. In some cases the female could be induced to discharge her eggs by gently stroking the ventral side of the abdomen with

TABLE 3.—EFFICIENCY OF NATURAL FERTILIZATION OF *H. limbata* EGGS AS SHOWN BY HATCHING EXPERIMENTS.

Origin of females	Lot number	Number females stripped	Total eggs examined	Number eggs hatched	Per cent eggs hatched
Pine Lake	1	1	209	200	95.7
Pine Lake	2	1	389	379	97.4
Pine Lake	3	1	517	510	98.6
Pine Lake	4	1	421	419	99.5
Pine Lake	5	12	761	742	97.5
Pine Lake	6	1	851	842	98.9
Pine Lake	7	1	926	905	97.7
Gun Lake	8	1	248	238	96.0
Gun Lake	9	1	686	626	91.2
Gun Lake	10	1	234	226	96.6
Gun Lake	11	50	1,621	1,511	93.2
Au Sable River	12	1	351	338	96.3
Au Sable River	13	15	436	427	97.9
Au Sable River	14	22	457	442	96.7
Au Sable River	15	1	269	265	98.5
Total		110	8,376	8,070	96.3

a dissecting needle. In most instances, however, it was necessary to dissect the ovaries. The macerated sexual organs of the male were then mixed with the eggs and allowed to stand for 1-2 minutes, after which the eggs were placed in water in glass containers of various kinds. About 45 seconds after coming in contact with water, they became sticky and began to adhere to the glass. At the end of 3 minutes all were firmly attached and remained so during incubation and hatching. This adhesive property made it very convenient to handle them since they remained in place at all times.

Results of artificial insemination and incubation varied greatly, for the percentage of eggs which hatched ranged between 2.7 and 88.6. Poor fertilization resulted when adults used were old and dying. *Imagoes and subimagoes proved to be equally fertile, showing that ova and spermatozoa are fully mature when the winged fly first emerges.* One attempt to fertilize eggs from a female subimago with the sexual elements of a last instar male nymph whose wing pads were quite dark was unsuccessful.

INCUBATION

Published accounts of the incubation period of *Hexagenia* vary greatly. No temperature records were given by Clemens (1913, 1915, 1922) when he stated that in two instances eggs

of "*H. bilineata*" hatched in 36 days and in a third from 29-40 days. Eggs of *H. l. occulta* from Lake Winnipeg hatched in 17-19 days at temperatures ranging from 18°-23° C. (Neave, 1932). Spieth (1938) succeeded in hatching eggs of *H. occulta* in the laboratory in 14 days and in a nearby stream in 20 days.

Length of incubation is important since a short one means a longer growth period for newly-hatched nymphs during the remainder of the summer. Temperature is an important factor influencing rate of embryonic development. In the laboratory at temperatures ranging from 75°-95° F., hatching began in 11-14 days. Eggs incubated under temperatures ranging between 67° and 81° F. began hatching at the end of 18-22 days. Where eggs were scattered on the bottom of containers, hatching of all eggs was virtually completed within 4 days after it started. In other instances, to be discussed later, where masses of eggs had clumped together, newly-hatched nymphs continued to appear for many weeks. Eggs placed in 2-quart jars and submerged in the East Branch of the Au Sable River began hatching after 20-26 days at temperatures ranging from 62°-73° F.

Effect of temperature was determined more specifically in the following experiment. A portion of the eggs obtained from naturally fertilized females (Lots 2, 5, 10, Table 3) was placed in quart jars in a refrigerator (36°-40° F.) 8 days after incubation began. Jars were removed from the refrigerator 70 days later and the eggs allowed to incubate at room temperature (68°-80° F.). Hatching began 16 days later and was completed in about 4 days, total elapsed time since fertilization being 94 days. The total 26-day incubation period at room temperature was slightly greater than that for the controls (20 days) and the percentage of successful hatching was nearly the same. It can be concluded that embryonic development was extremely slow or that a state of dormancy existed while the eggs remained at 36°-40° F., and that no ill effect resulted from exposure to low temperatures. It is quite possible that eggs deposited in late summer in natural waters may remain alive over winter and hatch successfully when water temperatures rise in the spring. It is also probable that eggs which settle in deep water below the thermocline, providing sufficient oxygen is present, may require several months for embryos to mature.

A greatly prolonged incubation period of *H. limbata* eggs

occurred in several instances under similar circumstances. Eggs stripped from 50 females captured at Gun Lake, July 1, 1947, were all placed in a 2-quart jar and incubated in the laboratory (Lot No. 11, Table 3). Hatching first began July 19, after 18 days of incubation. Within a week more than half of the eggs had hatched but a diminishing number of nymphs continued to appear until November 6, 1947, 98 days after the start of incubation. Circumstances surrounding the position of eggs in the incubation jar, later duplicated with similar results, seemed to influence drastically the rate of embryonic development. Examination revealed that in some areas on the bottom of the container, eggs were piled on top of each other 10-20 layers deep and solidly attached together by the naturally adhesive material around them. Those on the periphery of these masses, and those located singly or in layers no more than 3 eggs deep, hatched within 3 weeks. Embryos within these masses, however, developed very slowly, those nearest the center hatching last of all. Reasons for this delayed development are not known, but the conclusion must be reached that some condition resulting from the crowding or smothering of these eggs retarded their development. Even though these embryos developed slowly, most of them eventually hatched (Lot No. 11, Table 3). Similar results were obtained by covering eggs firmly attached to the bottom of jars with 2-3 inches of stream silt. In these cases development of embryos was greatly retarded so that hatching did not occur until 2-3 weeks after uncovered eggs in jars in the same stream had produced nymphs. These experiments suggest that eggs covered by silt in natural waters take much longer to hatch than those exposed, and that embryos may be killed from being buried. Prolonged hatching has been observed among eggs of other mayflies but details of the conditions of incubation were not given. Ide (1935) found that eggs of *Stenonema canadense*, incubated in a glass container, hatched over a period of 6 weeks and that there was evidence to indicate that eggs of *Iron pleuralis* remain in an unhatched condition in the stream for at least 4 months.

Effect of desiccation on fertilized eggs was determined in 9 cases by dividing eggs both artificially and naturally fertilized into two groups. One group, serving as a control, was placed in water immediately and the other dried at air temperature for periods ranging from 4-72 hours before being placed in water and incubated. In all cases, nymphs hatched from the

control eggs but none were produced from, nor did any embryonic development occur in, the desiccated eggs.

SUMMARY

1. Examination of the ovaries of 24 female imagoes revealed that the number of eggs produced ranged from 2,260 to 7,684. A positive correlation exists between body length and number of eggs produced. An average size female produces about 4,000 eggs.

2. Eggs were deposited on the water surface in three ways. In most instances ovipositing females plunged erratically to the water surface, then discharged their eggs within a few seconds and drowned. Occasionally females alighted upright on the water, discharged a few eggs, took wing and repeated the procedure. In a few cases females extruded their eggs in mid-air and dropped the egg packets from a height of 10 to 20 feet.

3. Eggs deposited in lakes either become attached to aquatic vegetation and other solid objects or come to rest on the mud surface. Eggs sink in still lake water at a rate of 1 foot in 80 seconds.

4. Eggs obtained from 110 naturally mated females were incubated in the laboratory. The percentage of eggs which hatched ranged from 91.2 to 99.5 (average 96.3).

5. The incubation period is greatly influenced by water temperature. Eggs hatched within 11 to 14 days when water temperatures ranged from 75° to 95° F., and within 20-26 days at a temperature range of 62° to 73° F. Eggs kept at 36° to 40° F. for 70 days apparently lay dormant while refrigerated, but later hatched when returned to room temperature.

6. Eggs which were air dried for 4 hours or longer before incubation began failed to hatch.

LITERATURE CITED

Clemens, W. A.

1913. New species and life histories of Ephemeridae or mayflies. Canad. Ent., 45: 246-262.

1915. Rearing experiments and ecology of Georgian Bay Ephemeridae. Contr. Canad. Biol., 139: 114-143.

1922. A parthenogenetic mayfly (*Ameletus ludens* Needham). Canad. Ent., 54: 77-78.

Eaton, A. E.
1871. A monograph on the Ephemeridae. Trans. Entom. Soc. London, 1: 1-164.
1883. A revisional monograph of recent Ephemeridae, Part 1. Trans. Linn. Soc. London, Zoology, 2nd Ser., 3: 1-77.

Ide, F. P.
1930. Contribution to the biology of Ontario mayflies with descriptions of new species. Canad. Ent., 62: 204-213.
1935. The effect of temperature on the distribution of the mayfly fauna of a stream. Univ. Toronto Studies, Biol. 39, Publ. Ont. Fish. Res. Lab., 50: 3-76.

Lyman, F. Earle
1940. Limnological investigation of the Ephemeroptera in Douglas Lake, Cheboygan County, Michigan, with special reference to the distribution of immature stages. Unpublished thesis, Univ. of Mich. Library.

McDunnough, J.
1924. New Canadian Ephemeridae with notes, II. Canad. Ent., 56: 90-98.
1927. Notes on the species of the genus *Hexagenia* with description of a new species (Ephemeroptera). Canad. Ent., 59: 116-120.

Morgan, Ann H.
1913. A contribution to the biology of mayflies. Ann. Ent. Soc. Amer., 6: 371-413.

Neave, Ferris
1932. A study of the may flies *(Hexagenia)* of Lake Winnipeg. Contrib. Canad. Biol. Fish., N. S., 7: 179-201.

Needham, James G.
1920. Burrowing mayflies of our larger lakes and streams. Bull. U. S. Bur. Fish., 36: 267-292.
1927. The life history and habits of a mayfly from Utah. Canad. Ent., 59: 133-136.

Needham, James G., Jay R. Traver and Yin-Chi Hsu
1935. The biology of mayflies. Comstock Pub. Co., N. Y., 759 pp.

Spieth, Herman T.
1938. A method of rearing Hexagenia nymphs (Ephemerida). Ent. News, 49: 29-32.
1940. Studies on the biology of the Ephemeroptera. II. The nuptial flight. Jour. N. Y. Ent. Soc., 48: 379-390.
1941. Taxonomic studies on the Ephemeroptera. II. The genus *Hexagenia*. Amer. Midl. Nat., 26: 233-280.

Ulmer, George
1921. Über einige Ephemeropteren-Typen älterer Autoren. Arch. f. Naturg. Abt. A., 87: 229-267.

ENTOMOLOGICAL OPPORTUNITIES [1]

M. C. VAN HORN
Florida Agricultural Supply Company, Jacksonville

It's a pleasure and an honor to be here today among this group of distinguished gentlemen who have such a vitally important role in America's multi-billion dollar economy.

Entomology, the branch of zoology that treats of insects, has grown to become a profession that affects the lives of virtually every living person on this earth today.

Only the other day, a friend of mine introduced me to a group of people. He said, "I want you to meet M. C. Van Horn, an entomologist."

One of the persons in this group shook my hand and said, "Oh, a 'bug-man'. Isn't that right?"

I nodded. "I suppose that's what you might call it," I told him.

"In that event," he said, "I guess you know some of the answers about bugs."

"We try to keep up with current entomological problems," I replied.

"Then tell me, Mr. Van Horn," he said, "if ants are such busy insects, how do they find time to go to so many picnics?"

Seriously though, it hasn't been many years since people looked upon entomologists as weird and curious creatures. They were characterized as having long hair, wearing unusual costumes and flitting around the country with nets chasing butterflies.

Today, the public has been educated to a better understanding of the entomologist and his contributions to a more gracious living. The average person knows that the entomologist is, indeed, an expert in his field.

And by the way, speaking of experts, there are all kinds of definitions for an expert, too. One of the best I've heard, though, is "An expert is a fellow with a Phi Beta Kappa key on a gold chain, but no watch on the other end of the chain."

Anyhow, you know, and I know, that the economic entomologist has little time for chasing butterflies in this day and age. *The pesticide industry, according to recent estimates, has developed into a 150 million dollar a year business.* Pesticides

[1] A talk given by Past-President M. C. Van Horn (1948-1949) at the 33rd Annual Meeting of the Florida Entomological Society, December, 1950.

manufactured to day are used to combat insects, fungi, bacteria, rodents, weeds and all kinds of parasites.

The importance of pesticides can better be appreciated when we are told that insects cause an annual damage to American crops, livestock and property of more than two billion dollars. This yearly two billion dollar loss does not include the damage from plant diseases, which, according to recent estimates, annually costs agriculturists and horticulturists another two billion dollars.

We may find it hard to believe these staggering figures, but not so hard, perhaps, when we consider that there are in existence today a horde of insects and more than 50,000 different plant diseases. For example, corn is susceptible to some 114 diseases. There are 200 diseases that attack apples and 127 with which potatoes are afflicted.

Many of these control problems have us baffled. Nature, we have discovered, has a way of building up immunity in some pests to certain pesticides. We have learned, for example, that mosquitoes and flies have developed a certain amount of immunity to DDT.

Thus there is a tremendous challenge in the field of entomology. Where challenge exists, opportunity is nearby. History has proven this.

Speaking of mosquitoes, I wish nature would provide man with some kind of immunity against these pests. You have probably heard one of the definitions of a mosquito—a small insect designed by the good Lord to make us think better of the fly. Most mosquitoes, incidentally, are pretty smart. They all seem to pass the screen tests.

In this world of ours today, there is virtually nothing that man or animal eats, inhabits or wears, with the exception of metallic objects, which is not subject to pest problems at some stage of its development or use. It is up to the entomologist and his associates, directly or indirectly, to solve these pest problems.

The problems of the economic entomologist, therefore, involve food, fiber, health, structure, soil, animals, forest, grass, ornamentals, stored products—the list seems almost endless. The entomologist is concerned not only with the destruction of pests and the protection of products, he deals also with constructive insects such as the honey bee. The entomologist is highly concerned, too, with the health problem that arises in the

production, processing, handling and use of toxicants in combating pests.

Although the term pesticide is comparatively new, the science itself goes far back in history. The findings of archeologists indicate that certain chemicals were used to combat pests a thousand years before Christ. Many of the new discoveries and improvements we are making and developing today have been made possible only by the detailed scientific work accomplished by pioneering entomologists—our forefathers. The more I delve into the history of the development of pesticides, the greater becomes my respect and admiration for the painstaking work, study, records and accomplishments of these pioneer entomologists. Without their early basic scientific studies to rely upon, our progress today would be greatly impeded.

Today, the opportunities for well qualified entomologists are arising at a greater rate than at any time since the profession was known. Throughout the entire world, for reasons of health, for reasons of security and for reasons of economy, people are realizing the vital importance of knowing the answer to this question "who are my friends and who are my enemies?" You know and I know that in a rapidly moving, quickly progressing business world it is highly important to know our enemies from our friends. But we cannot stop there. It is important that we know our enemies from our friends in the lower animal kingdom—and specifically, the so-called pests.

The entomologist can pride himself on the fact that the problems on which he is working are not merely local, state-wide or even continental in scope. These problems are world-wide. In solving them, he is contributing to the welfare of the world.[2]

The measures employed by the entomologist in dealing with these problems are complex. They involve law, psychology, physiology, chemistry, physics, ecology, transportation, processing, engineering, salesmanship and diplomacy, not to mention some mechanical knowledge.

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[2] Records indicate that as a citizen of the U. S. A., we now enjoy the largest life expectancy in our history. We believe at least a part of this accomplishment can be attributed to the advancements made in science, of which the entomologist, through public health, abundant and quality food production can claim a part.

One hundred years ago it took 4 people to produce food for themselves and 1 person in town. Today 2 people on the farm produce enough food for themselves and 8 people in the town plus 1 person in other nations. This tremendous increase in production would not have been possible without the services of the entomologist and the pesticides in use today. In fact, without them it is probable that the world today would go hungry.

An entomologist—that is, a good one—needs far more than a working knowledge of entomology. He should have a basic understanding and some training in such subjects as chemistry, pathology, botany, horticulture, toxicology, agronomy, agriculture, public speaking, English composition, journalism, statistics, salesmanship, public relations, advertising and business administration. He should know how to make friends and influence people—how to use a camera. On top of all this, modern society demands that he play a reasonably good game of golf, know how to hook a sailfish, be an understanding partner at bridge and a genius at canasta. Confidentially, where that canasta part is concerned, I am working on a pesticide to combat that problem. It may take a lot of time. Mrs. Van Horn is not cooperating.

The formal education of an inexperienced entomologist might be likened to the development of an embryo. The seed has been sown, it is assumed they have fallen on fertile ground and that normal development will take place to form the sprouting or graduation. This formal phase of education basically prepares the student for his future work. In other words, it places a tool in his hand with which to work and develop. This training should give him an advantage over those who are not so prepared; however, this in itself does not assure success.

The knowledge gained must be diligently and intelligently applied. Usually there is a practical application learning period which might be likened to an internship. This may continue for several years before the candidate reaches his entomological majority.

There is little question that the need for well qualified entomologists has never been greater than it is today and the opportunities were never brighter. The requirements are broad, the road to success is not easy but to those who have what it takes the way is open.

The very fact that you are here today is an indication that you have what it takes. The very fact that you are interested enough in our problems to come here and thrash them out means that you are interested, not merely in your personal and local entomological problems, but in the science and profession of entomology as it affects the welfare of the world.

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